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ABSTRACT

Over the past decade educational researchers and curriculum evaluators have dealt with the deviation between a specified educational program and its actual implementation. These differences have been referred to as a critical problem in both the achievement and the evaluation of a program's goals. The research reported here has explored the grassroots implementation of computer-use in classrooms as an alternative approach to program implementation. An ethnographic study of six exemplary elementary classrooms in the San Diego County (California) area found that successful implementation of computers was the result of the combined efforts of an enthusiastic teacher, who became the "computer expert," and a supportive principal, who in most cases did not know about computers but recognized their potential. These implementation efforts resulted in applications that were different from conventional uses, and were evaluated against heterogeneous criteria of success. Diversity in the implementation of computers in education was found to be a useful mechanism for coping with the rapid rate of change in computer technology. The grassroots introduction of computers required extensive efforts on the part of the teachers involved and resulted in the recognition of their academic effort by colleagues. If the implementation of computers had followed the traditional top-down hierarchical approach, it could not have kept abreast of rapid technological changes and might have become overly constrained in its application. (23 references) (Author/GL)

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Interactive Technology Laboratory

Report #12

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ABSTRACT

Over the past decade educational researchers and curriculum evaluators have dealt with the deviation between a specified educational program and its actual implementation. These differences have been referred to as a critical problem in both the achievement and the evaluation of a program's goals. The research reported here has explored the grassroots implementation of computer-use in classrooms as an alternative approach to program implementation. A study of six "exemplary" classrooms found that successful implementation of computers was the result of the combined efforts of an enthusiastic teacher, who became a "computer expert," and a supportive principal, who in most cases did not know about computers but recognized their potential. These implementation efforts resulted in applications that were diverse from conventional uses, and were evaluated against heterogeneous criteria of success. Diversity in the implementation of computers in education was found to be a useful mechanism for coping with the rapid rate of change in computer technology. The grassroots introduction of computers required extensive efforts on the part of the teachers involved and resulted in recognition of their academic effort by colleagues. We conclude that the problems experienced in the past with the diversity of curriculum implementation was an asset in the case of educational computer-use. Program developers may find it useful to explicitly encourage motivated teachers to explore diverse applications of computer supported curriculum while continuing to focus on the critical pedagogical features.

Exemplary Educational Computer Use:

Coping with Rapid Changes in Technology

A national survey of classroom computer use (CSOS, 1983) documented a rather consistent pattern at both the elementary and secondary levels. On the average, the majority of the students' time was committed to writing computer programs. Drill and remedial CAI was the next most prevalent use. Considering per-user contact time, more sites reported CAI as the primary use of computers than any other application. Almost no instructional time was reported for using the computer as a tool for composing and editing text, graphics or music or as an aid in communication.

This pattern of computer use is somewhat surprising. First, the full interactive capability and range of microcomputers are not being exploited when microcomputers are used for basic skills instruction and programming. While there is some evidence to suggest that microcomputers can deliver basic skill instruction better than conventional techniques, the utility of doing so diminishes when their cost is taken into consideration (Tucker, 1983). Second, the use of computers for basic skill instruction and programming does not match the needs of the world of work, where microcomputers are used for text editing, spread sheet analysis, and data base management.

While such reports (CSOS, 1983; CUSG, 1983; Becker, 1986) provide descriptions of how computers are currently being used in classrooms, future trends remain unclear. To gain some insight into future uses, we carried

out a study of "exemplary computer uses" in schools.

Exemplary Site Study

To identify the salient features of successful implementations of computers uses in instruction, we conducted an in-depth ethnographic study of six exemplary classrooms in the San Diego County area. Our goals were to identify the range of characteristics likely to lead to successful use of computers in classrooms.

Method

The selection of exemplary sites could not be based on an *a priori* predetermined model of how schools should use computers because of the lack of agreement on what the ideal model should be (Papert, 1980; Johnson, Anderson, Hansen & Klassen, 1980; Luehrmann, 1981; Anderson, Klassen & Johnson, 1981). Therefore, we decided to rely on the methodology of anthropological research, in which the advice of local informants is used to discover features of the environment considered by the local inhabitants to be most important. In our case, we approached key educators in San Diego County, and asked them to identify local schools that they recognized as being exemplary users of computers in the classroom.

Potential sites were identified by the resource teachers from the San Diego Teacher Education and Computer Center. The sites were well known to the group and there was clear agreement on the final selection. We were struck by

the observation that while our informants easily identified exemplary computer-use classrooms, they used different sets of criteria of excellence. One school was identified because it provided sound training to students for the job market, another for the motivation and dynamic nature of the teacher, a third for its widespread use of computers throughout the school and another for the level of programming skill achieved by students. We selected six of the 14 schools proposed by the resource teachers for in depth study. The schools were selected to provide a range of grade levels (2 elementary, 2 middle school and 2 high schools) and a range of locations throughout San Diego County.

Four interviews and eight observations were carried out in each school during the Spring of 1983 by undergraduate students participating in a course on computers and education at the University of California, San Diego. Each student received training in interview and observation methods and was assigned to one of the schools. A detailed observation schedule and interview guide was prepared. To provide a check on reliability, one additional student made independent observations in all six schools. This was followed by a series of follow-up interviews of administrative personnel at each site. The following issues were addressed:

- Methods of introducing computers to school
- Parental and community involvement
- Placement of computers in the classroom and the school
- Availability of computers and student access
- Hardware and software choices, problems and solutions
- Computer lessons, preparation and execution

- Integration of computers into curriculum
- Technical support required and sources available
- Impact of computers on students and teachers
- Projections for the near future

Descriptions of the Six Schools

Eucalyptus Elementary School serviced approximately 400 students in grades K-6. The students in the exemplary classroom were in grades 3, 4, and 5, and were selected by the teacher based on applications completed by parents. The school had one Apple II computer on a movable cart which was located most of the time in the back of the exemplary classroom. The students engaged in a range of activities including word processing, real time communication with special education students in another school, data base management, graphics and animation, and programming in BASIC and LOGO. Students were scheduled to use the computer in pairs throughout the school day while the other students were engaged in whole class lessons with the teacher. Occasionally, the students rolled the computer to other classrooms to provide computing experience for the rest of the school.

The second classroom was at **Ebony Elementary School**, a district-wide "Computer Magnet." The teacher used 23 Apple II computers, interconnected in a "local network" in a computer laboratory setting. Other teachers in this school scheduled their classes into the computer lab once a week for 30 minutes. The computer teacher then conducted the lessons in the lab, focusing more than 90% of the time on LOGO programming. The rest of the time he used

social science simulations and educational games. The teacher had the responsibility for providing computing experience for all of the K-6 students in the school.

Maple Secondary School was a district-wide Math, Science and Computer Magnet (grades 7-12). The classroom observed serviced grades 7-9. The school had over 30 Apple II computers, eight Pet computers and 32 terminals attached to a main-frame computer. The teacher focused on BASIC programming, building on algebra as a prerequisite and leading to FORTRAN and Pascal programming at the senior high level. Seventh and eighth grade "magnet" students who were specially selected for this program, worked with the computers during a two week period each month. The ninth grade magnet students worked with the terminals throughout the school year, working in pairs for fifty-five minutes each day on BASIC programming.

Mahogany Middle School had a computer program that serviced all sixth grade students and offered elective BASIC courses for some seventh and eighth graders. The school computer laboratory employed twelve VIC-20 computers (interconnected in a local network) and two Apple II computers. The two Apple computers were occasionally rolled to other classrooms for demonstrations. All sixth grade teachers scheduled their classes into the lab one hour a day for nine weeks. All computer instruction was provided by the computer teacher. The curriculum, prepared by the computer teacher, consisted of a series of short BASIC programming exercises. Students worked in pairs at their own pace.

At **Hickory High School**, the computer literacy program was developed by

members of the Business Department faculty. The course consisted of word processing, BASIC programming and some data processing instruction. The business classroom used 23 TRS-80 Model III computers. The computer teacher's goal was to provide writing and other job entry skills to the largely minority students in this school. The teacher had five classes of about thirty juniors and seniors each day. The students used word processing in this business course to write their English compositions and other writing assignments for their classes.

Hemlock High School was situated in a more affluent area than the other sites. The computer lab had 13 IBM Personal Computers and one Apple computer. The teacher taught three courses in computer literacy and also supervised periods of independent use. The curriculum focused on the use of a wide range of computer tools such as word processing, spread-sheet programs, graphics and animation editors, simulations, data base systems, and some BASIC programming.

Results

Analysis Across Sites. The most common computer activities in these six schools were among the least commonly reported in schools throughout the country (CSOS, 1983). Four of the six schools used their computers to teach word processing, while according to the National Survey of School Uses of Microcomputers, word processing was used in only 3% of the elementary schools and 7% of the secondary (CSOS, 1983). Demonstrations, problem-solving using programming, and recreational games were also regularly employed in all

schools observed in our study, while nationally, these applications were reported in only about one-fifth of the schools with microcomputers (CSOS, 1983). None of the classrooms we observed were engaged in systematic drill and practice use of computers, which was the most common use in 59% of elementary and 31% of secondary schools in the country.

In general, we found that these exemplary classrooms were responding to the computer challenge by encouraging diversity of use and content, relying on unconventional resources and support, and employing heterogeneous criteria of success.

Diversity of Use and Content. The most salient feature of computer use in the six classrooms was the striking diversity of implementation and the implicit acceptance of this diversity by the administration. The hardware and software available in schools, the accessibility of computers to students, the activities and content considered appropriate, the arrangement of computers in the classroom, and the structure of lessons varied significantly across the schools.

The diversity and incompatibility of hardware among schools in itself is not a new finding (Miller, 1983; CSOS, 1983; Becker, 1986). Availability of funds, personal experience of teachers and constraints from the sources of funding are the obvious reasons that account for the differences. The diversity of attitudes of the teachers in our study towards the use of different hardware, on the other hand, was somewhat surprising. Some teachers intentionally exposed their students to different computers and terminals while others avoided using more than one system. In two schools, different

systems were used with the same students for different applications. One system was used for word processing and a different one for simulations and programming. In another school, more advanced students were assigned to the more expensive computers while the rest of the class used the less powerful (and less expensive) machines.

We also found diversity in the quantity vs. quality choice: some schools preferred fewer machines of a relatively expensive model while others preferred the opposite. This difference does not seem related to the absolute level of funding available: one (affluent) school had 13 IBM Personal Computers while another (less affluent) school, with roughly the same number of students per class, had 20 TRS-80 model III machines. One elementary teacher (in a less affluent school) used funds to acquire a single Apple II while another school in a more affluent neighborhood selected a local area network system employing 12 inexpensive VIC-20 computers.

Diversity in software and the type of instructional activities used paralleled the diversity in hardware. There were significant differences in the extent to which commercially available software was used. In the classroom that focused on LOGO instruction, students used specific procedures in LOGO, programmed by the teacher, in order to create artistic designs. The other elementary teacher taught his 4th-5th grade students to use a commercial database program to print attendance lists for the school office. These students also regularly used a commercial communication program to interact with handicapped students in another school.

All the teachers interviewed described having freedom of choice concerning the form and the content of computer classes. Most of the teachers knew their activities were different from classes at other schools but were not concerned with this disparity. Moreover, the teachers expressed interest in knowing more about activities in the other schools, looking for useful ideas to implement in their own classrooms.

Unconventional Resources and Support. There was considerable reliance on unconventional and informal resources in the schools observed. Teachers relied on friends or personal contacts to solve technical and management problems. Commercial computer magazines were consulted to identify high quality educational software. Teachers and principals approached businesses and funding agencies to "adopt" or support school computer facilities.

Most of the teachers spent many unpaid hours after school working with students and preparing materials for computer classes. Older students and parents were mobilized to serve as aides in computer classes. Parental interest in volunteering was so great at two of the schools that some had to be turned away. All the teachers observed spent extra time keeping their knowledge up to date, participating in conferences and computer-user groups, making professional presentations and introducing other teachers to computers.

The reliance on unconventional resources for support was not seen by the teachers as a criticism of district inservice personnel due to the following factors:

- The help required was extensive and technical in nature.
- Assistance was readily available from sources outside conventional district support facilities.
- Financial support was easier to obtain outside the educational system.

Heterogeneous Criteria of Success. The teachers were asked to assess what they regarded as their main achievements. One pointed to specific preparation for the job market, high enrollment for next year's courses and reduced absenteeism. Another indicated that due to experience with computers, students were excited by school and worked harder in all their classes. Others pointed to the programming capabilities of their students, the teachers' renewed interest in their work, the "Hawthorne Effect" on students (improved performance resulting solely from any change made in the environment), cooperation among students and independent self-paced learning. One high school teacher referred to his primary goal in the following manner:

> "The students are now comfortable with the computers, without the awe and intimidation previously felt by many. They are aware of computer capabilities, and may now be able to see a real world problem and know that a computer would be able to help to solve it . . . stressing the viewpoint of future computer users, not just programmers."

Of the six teachers interviewed, only one expressed surprise at being chosen as an exemplary case. Most of these teachers had been exposed to a constant flow of visitors. Several have been the subject of newspaper

articles. A recent film on computer-supported writing that was produced by a local education authority and distributed throughout the State of California for inservice purposes featured one of our classrooms. The teachers involved knew that their work and achievements were valued and they all expected to continue to their leadership role in the education community.

Discussion

We found that the computer related activities in the six schools observed were among the least common found in other schools throughout the country. However, considering the exemplary status and the visibility that these classrooms enjoy, we can predict that the direction of future trends in classroom computer use will be toward an increase in word processing and other computer supported tools, a decrease in drill and practice, and a reduced emphasis on programming as the primary skill associated with computer literacy.

What makes these sites exemplary is the attempt on the part of these innovative teachers to identify **alternative entry points** to computer literacy. By encouraging their students to work with a range of computer supported tools in order to carry out useful tasks in school, everyone in the class has an opportunity to succeed in some context. Though programming does not have to be restricted to high achievers (at two of our sites, every student learned some BASIC and/or Logo programming), programming has all too often been used as a "filter" to restrict access to computers.

As computers become more powerful and less expensive, learning to

program using a general purpose language will diminish in importance for the vast majority of the population. Currently, an individual is not required to learn to program to be an effective computer user. Certain skills will continue to be important such as editing and debugging, but these skills can be learned through the use of special purpose tools (Levin & Souviney, 1983).

Diversity in curriculum is not currently a general property of the conventional educational system. The movement is toward highly specified and centrally controlled curricular materials. Textbooks and district guides are generally specified using well defined goals and objectives. Often topics to be learned are carefully coordinated with specific teaching methodology. Standardized tests are considered objective verdicts of success or failure. Curriculum innovators often refer to the "problem of program implementation," meaning the variability ("distortions") found among different sites when implementing a new program. This variability, often attributed to teachers, is usually considered a hindrance to the success of the new program (Hall & Loucks, 1977; Fullan & Pomfret, 1977).

Diversity by itself is not sufficient to produce wide-spread and lasting change. For example, diversity has been characteristic of several previous curriculum reform efforts. The "New Math" curriculum of the 1960's and early 1970's was comprised of several competing programs, each based on different theoretical assumptions. Attempts in the late 1950's to reform pre-college mathematics instruction was an indirect outcome of the Bourbaki mathematics group in France, which attempted to describe deductively all of mathematics content from sets of axioms. Out of frustrations with the perceived lack of preparation of entering freshmen, university mathematicians

set about designing prototype secondary (and later elementary) mathematics curricula for the college bound student. These early efforts (i.e., School Mathematics Study Group) had a significant effect on the content and design of textbooks in the USA and in other countries (Thwaites, 1961, 1972).

Other mathematics curricula were based on particular psychological assumptions about how learning occurs (Howson, et al., 1981). Behaviorists (Gagne, 1962) created "programmed" textbooks (i.e., Greater Cleveland Mathematics Program); structuralists (Bruner, 1960) designed curriculum which took into account the underlying mathematical structure of the content (i.e., Comprehensive School Mathematics Program); developmentalists (Davis, 1964) approached mathematics instruction based on Jean Piaget's theory of cognitive development (i.e., Madison Project); those adopting an integrated approach proposed teaching mathematics through real world science and social science problem solving experiences (i.e., Unified Science and Mathematics for Elementary Schools Project).

Though there were scores of "New Math" programs and textbooks developed during the 1960's, the implementation of these curricula can generally be characterized as externally imposed upon classroom teachers. Significant involvement by practicing classroom teachers in the design of these programs was the exception rather than the rule. Teacher inservice training was, in general, underfunded or never considered an integral component of the curriculum's implementation. Teachers' Centers, which were moderately successful in providing professional growth opportunities in England, were never successfully implemented in the U.S.

The opportunity afforded by diverse approaches to teaching mathematics was not exploited in any one "New Math" program. Each approach offered a focused solution to the teaching/learning task. Each specified a unique pedagogy and set of activities that many teachers found difficult to adapt to personal teaching styles (NACOME, 1975).

In the case of educational uses of computers, diversity seems to be instrumental. The innovative teachers are inventing effective ways to implement the use of computers in their instruction. If we take into account the rapidly changing technology of computers, it may well be that variability is the only way to generate the innovative approaches required to effectively use computers in education. A more rigid strategy may be counter productive in the long run.

It is clear from previous studies (CSOS, 1983; CUSG, 1983; Becker, 1986) that the use of microcomputers in classrooms is significant and is likely to grow at an increasing rate over the next decade. But what will be the nature of future classroom uses and what will teachers and administrators need to know in order to more fully exploit the capabilities of this new interactive communication medium?

The failure of curriculum reform in the past (i.e., New Math; teaching machines) stemmed largely from the centralized nature of decision making and the failure of planners to effectively engage practitioners in their design and implementation efforts. Classroom computer-use seems to avoid this deficit since quality software allows for more instructional flexibility and decision making on the part of the teacher. Computer supported instruction

can serve to ameliorate the "linear" quality of curricula which has been characteristic of designed efforts employing traditional technology. Such software affords more distributed decision making on the part of the classroom teacher and a sharing of responsibility with the curriculum designer.

Will computers last in schools? Or, like other highly promoted educational innovations such as educational television or New Math, will they have a short lived existence? In evaluating the life expectancy of computers in schools, it is important to keep in mind that the impetus for their acquisition comes from sources which are external to the school. Computer manufacturers, computer-using businesses, and parents (fearful that their children will not develop skills needed in a technologically dominated marketplace) continue to pressure schools to teach students about computers.

The reaction of schools to this demand may very well determine whether computers stay in schools. If schools adapt their curriculum to meet, indeed even anticipate, the uses of computers in the world of work, then we can expect computers to be a viable part of schooling. Their viability will be increased to the extent that their impact on all aspects of the social system of the school is anticipated (Sarason, 1982).

If, however, schools continue to use computers as teaching machines for basic skill instruction through drill and practice, then we can expect computers to recede in importance in schools. People will learn the more compelling use of computers (e.g., text processing, telecommunications, spread sheet analysis, data management, music and graphic design) from

sources outside the schools. If people turn away from schools to learn about information technology, then this movement will have a profound impact on the structure and function of school as we know it (Illich, 1970).

There is widespread readiness on the part of school boards and administrators to support computer use in schools. Many teachers also appear to be willing to devote the time necessary to develop the required computing and classroom management skills for implementation. The community and business seem ready to assist.

The argument has been raised that these early developmental efforts with computer use in schools will eventually be replaced by a rather narrow "accepted notion" of the appropriate education use of computers. Some have prescribed a rigid pattern of computer use in which LOGO and drill programs will reign in elementary classrooms, BASIC in the middle schools and Pascal at the high school level (Bitter, 1984). Our prognosis is more optimistic.

It is true that in elementary schools, there has been a keen interest in LOGO both as an environment for learning planning, debugging and other problem solving skills, and as a specific tool for artistic design. But elementary schools are also using other software tools which provide opportunities for problem solving experiences: word processing, telecommunication, animation, simulations and special domain environments (i.e., construction sets). Moreover, some teachers, alert to promising new software, are enriching their instructional programs and creating innovative classroom applications. Several teachers are currently using an **Interactive Text Interpreter**, designed at UCSD, to develop activities in creative

writing (Mehan, Miller-Souviney, Riel, Souviney, Whooley & Liner, 1986; Levin, Riel, Rowe & Boruta, 1986; Miller-Souviney, 1985). Others are exploiting the telecommunication networking capability of computers to enable real and non-real time communication among students (Riel, 1983).

Conclusion

Computer supported software enables curriculum designers to create truly "non-linear" instructional sequences. The final decision of order, pace and content can, in large part, be left to the practitioner. Instructional systems based on computer technology can be far more interactive than curriculum employing traditional technologies, affording a capacity for distributed decision making, rarely found in the era of print technology.

If the implementation of computers in education followed the traditional top-down hierarchical approach, it could not keep abreast of the rapid technological changes and might become overly constrained in its application. Using a traditional approach to curriculum development, district level personnel would arrange for systematic evaluation in order to decide which specific type of use to recommend for various groups of students. They would next design curriculum and supporting teaching materials, arrange inservice and proceed with the introduction into the schools. The amount of time necessary for changes of this type to be introduced would be too long to take advantage of current technology. By the time the chosen approach was installed in the schools, it would be significantly outdated.

The diversity of accepted implementations, the heterogeneous definition

of what counts as achievement and the availability of unconventional support and resources, together form a supportive environment in which teachers are able to experiment with the use of computers in their work, create new forms of use and keep up with the rapid technological change. The immediate effect on classroom instruction seems to be an increased involvement on the part of teachers and more enthusiasm from the students.

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